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Grades and standards have been used in the marketing of eggs for a number of years. During this period, there has been a tremendous improvement in the quality of eggs available to consumers in retail channels. Were it not possible to separate the low quality from the high quality eggs our quality grading program would not have developed.

Grades and standards make it possible to buy and sell on the basis of quality as well as quantity. Grades and standards also facilitate the marketing of eggs by making it possible to: (1) buy and sell by description rather than the physical inspection: (2) carry on future trading; (3) make more efficient use of storage and transportation, and (4) facilitate financing.

Egg grades are descriptions of a number of characteristics which divide those on the market into two or more groups. A good set of grades must cover the products being produced and marketed, and must reflect characteristics that all buyers recognize and which influence the amounts they are willing to pay. Also, the grading process must be based on factors that are dependable and can be uniformly and economically applied. Grades are of little value if there is no accurate method of placing the product in the various grades.

Grading eggs involves the process of rating and ranking the eggs on such characteristics as texture of the shell, the size of the air cell, firmness of the white, and the outline of the yolk. For a number of years candling has been the predominant method of grading shell eggs for interior quality. The candling process involves consideration of these four or five characteristics in every egg. Each of these characteristics must be considered in relation to the others.

These characteristics are a gradual shading from one unit to the next and the grouping into grades becomes an arbitrary decision. Since human judgment is involved in evaluating these characteristics, there will be variations or disagreement between candlers in the grading process.

Objectives of the following tests of accuracy or variability in grading were to detect the variation that exists between different candlers in the grading of identical samples of eggs, and the influence that this variation would have upon the value of the eggs.

## Experimental Procedure

In order to evaluate the actual extent of the variation in the grading of eggs by different candlers, the candling operations in two plants were studied. In these egg assembling plants each egg was individually hand candled for interior quality with a standard candling lamp and graded for size by a machine. The grades were determined on the basis of the U.S. Department of Agriculture Standards. Neither plant separated out the "AA" quality eggs, but included them with the "A" grade.

In most of the previous research on candling accuracy, candlers knew they were being tested and were naturally more careful in their work than under ordinary conditions. This experiment was purposely designed to keep the candlers from knowing that their grading was being checked in order to eliminate any effect that might otherwise result.

At 12 irregular monthly intervals, the investigators entered the plants after the candlers had finished work for the day. A random selection was made of cases of different grades of eggs that had been graded that day by one or possibly two of the candlers to be tested. Using these graded eggs as a source of supply, identical samples of 720 eggs (2 cases) were prepared for each candler to be tested in the plant.

The identical samples or "test cases" of eggs were prepared by arranging the empty cases in a row and then taking at random from the supply case of Grade A-large eggs a total of 18 eggs and placing them in the bottom filler on one side of each of the sample or test cases being prepared. In a similar manner 12 Grade B-large eggs were selected from the supply case of Grade B-large eggs and put in the same filler and 6 Grade C eggs were selected from the supply case of this grade to finish filling the filler in the sample case.

Each of the other 9 fillers in every sample case was filled in the same manner. Each completed sample or test case contained 180 Grade A Large, 120 Grade B Large and 60 Grade C assorted size eggs according to the original grading.

Each sample or test case of eggs was then identified with a "case card" with the name of a fictitious producer and the number of eggs in the shipment filled out in a manner similar to the case card on a regular shipment from a bonafide producer. The two test cases of eggs were then placed in the supply of cases of ungraded eggs to be graded the next day by each of the candlers to be tested.

Results of the grading of samples or test cases were recorded on the case card in the regular manner and the case cards taken to the office along with the case cards bearing the grading results on the eggs from actual producers. The data on the grading of the sample or test cases of eggs was secured by the investigators after the case cards reached the office.

In the two central egg assembling and grading plants included in this study, the candlers graded the eggs for interior quality into Grade A, B, C, Checks and Inedibles. Candlers placed the A and B grade eggs on a sizing machine which separated the A and B grade eggs into the various sizes, including; Jumbo, Large, Medium and Small. The grade C eggs were not size graded. The actual number of eggs placed in each grade was recorded at Plant No. 1, while at Plant No. 2 the number of eggs placed in each grade was rounded to the nearest number of dozens.

A total of 48 tests were conducted - 24 at each plant. In half of the tests white eggs were used and brown eggs were used in the other half. At Plant No. 1, three candlers graded the white egg samples and three candlers graded the brown egg samples. At Plant No. 2, two candlers graded the white egg samples and two graded the brown egg sample. Twenty-seven different candlers participated in one or more of these tests during the year.

## Results of Tests of Egg Candling Accuracy

In each of the 48 tests of the grading of identical samples of eggs by the different candlers, considerable variation was found in the number of eggs placed in the various grades. There was also considerable diversity between the original grading and the second grading of the same eggs by the same individual, as well as between the different candlers being tested. The differences in the number of eggs placed in each of the three quality grades (Grade A, B, and C) on the first and second grading were highly significant in 117 of the 120 tests.*

In order to determine the variation between candlers in the grading of the different grades of eggs in identical test samples, the results were analyzed separately for each grade.

1. Grade A Eggs: There were 360 Grade A eggs in each test sample according to the original grading, but on the second grading there were from zero to 614 eggs per test sample classified in the Grade A category at Plant No. 1. (Table 1).

In the total of 72 test samples, 31 samples showed more Grade A eggs on the second grading than were placed in the test samples according to the original grading. The number of eggs classified as Grade A regardless of size in the grading of 42 identical test samples at Plant No. 2 ranged from 108 to 636 eggs. At this plant 21 of the 24 brown egg tests contained over 360 Grade A eggs on the second grading, and half of the white egg samples contained more Grade A eggs than the 360 placed in Grade A on the original grading.

2. Grade B Eggs: In the 72 test samples at Plant No. 1, 48 samples contained more Grade B eggs in the second grading than in the initial grading. Thirty-one of these were white egg samples and seventeen were brown egg samples. While each sample contained 240 Grade B eggs according to the original grading, the number of Grade B eggs found per test sample on the second grading ranged from 188 to 666 in the white eggs, and from 28 to 560 in the brown eggs.

* Using the chi-square method of analysis.

In the 42 samples at Plant No. 2, ten of the white eggs and two of the brown egg test samples contained more Grade B eggs on the second grading than in the original grading. The number of Grade B eggs found in the identical test samples on second grading varied from 36 to 504 in the white egg samples and from 0 to 336 in the brown egg samples.

3. Grade C Eggs: The number of eggs classified as Grade C in the identical test samples by the different candlers in the 12 tests at Plant No. 1 varied from 21 to 125 in the white eggs and from 21 to 165 in the brown eggs. At Plant No. 2 the number of Grade C eggs found in the identical test samples varied from 12 to 276 in the white eggs, and from 36 to 132 in the brown eggs. In the 36 tests of individual graders of white eggs at Plant No. 1, only one test contained more Grade C eggs than were placed in this classification in the original grading; and in the 36 tests of individual graders of brown eggs, only three tests show more Grade C eggs than were placed in this classification in the original grading.

Table I

The average and the extremes in the number of eggs placed in each grade by the different candlers grading identical test samples of eggs.

| | Grades of Eggs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | | | B | | | C | | |
| Original Grading (Expected Number) | 360 | | | 240 | | | 120 | | |
| | Low | Ave. | High | Low | Ave. | High | Low | Ave. | High |
| Plant No. 1 White Eggs | 0 | 247 | 471 | 188 | 358 | 666 | 21 | 71 | 125 |
| Plant No.1 Brown Eggs | 30 | 372 | 614 | 28 | 246 | 560 | 21 | 68 | 165 |
| Plant No. 2 White Eggs | 108 | 359 | 576 | 36 | 223 | 504 | 12 | 96 | 276 |
| Plant No. 2 Brown Eggs | 288 | 485 | 636 | 0 | 115 | 336 | 36 | 73 | 132 |

In the 42 samples at Plant No. 2, there were 10 samples that contained as many or more Grade C eggs on the second grading compared with the number of Grade C eggs in the original grading; eight of these were white egg samples and two were brown egg samples. In the test grading at Plant No. 1, an average of 71 Grade C eggs were found in the white egg test samples and an average of 68 Grade C eggs in the brown egg test samples; while at Plant No. 2 an average of 96 Grade C eggs were found in the white egg test samples, and an average of 73 Grade C eggs in the brown egg test samples.

4. Checks and broken eggs: The number of cracked eggs or checks found in the test samples was fairly constant for the eggs of each color, in each test, except for one test sample of brown eggs at Plant No. 2, which had 179 checked eggs. This case of eggs must have been mishandled.

In Plant No. 1 an average of 19.1 checked eggs were found per test sample in the white eggs and 21.3 checked eggs in the brown eggs; at Plant No. 2 an average of 33.6 checked eggs were found in the white eggs and 57.9 checks in the brown eggs.

Undoubtedly a number of the checked eggs found in the second grading were eggs which were cracked in the process of grading and packaging and came from the Grade C class in the original grading, since eggs with thin or weak shells must be placed in the Grade C class.

5. Blood and Meat Spot Eggs: Some eggs with blood or meat spots were found on the second grading that were apparently missed in the original grading. More brown eggs than white eggs were found with blood or meat spots in the grading of the test samples at Plant No. 1 and fewer at Plant No. 2.

The number of eggs with blood or meat spots found on the second grading varied from 0 to 49 eggs per test sample at Plant No. 1 and from 0 to 35 eggs per test sample at Plant No. 2.

The average number of eggs with blood or meat spots found per test sample in the second grading was 5.6 eggs in the white eggs and 7.8 in the brown egg samples at Plant No. 1. In the Plant No. 2 the average number of eggs per sample with blood or meat spots was 5.3 in the test samples of white eggs and 3.1 in the brown eggs.

6. Size Grades: Based on the original grading, each test sample contained 360 Grade A Large, 240 Grade B Large, and 120 Grade C assorted size eggs, but the same eggs on second grading contained a large number of Grade A eggs which fell into the Jumbo, Medium and Small size grades, and some Grade B eggs which fell into the Medium size grade.

This discrepancy in sizing of the same eggs between the original and the second grading can be accounted for in part by the fact that some of the eggs that were classed as Grade C "assorted size" in the original grading were placed in Grade A or Grade B on the second grading and consequently were size graded on the second grading. Some of this discrepancy in size grading may also have been due in part to improper adjustment of some of the sizing machines.

When both the original and the test grading was done by the same candler, there were substantial differences between the first and second grading. The 48 Chi-Square values computed for comparing the original and the test grading of the same samples of eggs by the same candler were all significant except one. These tests indicate that the individual candlers were not consistent in grading eggs into the different egg quality classifications from day to day.

In 10 of the 12 tests, the sample was made up of eggs that has been previously candled by just one of the candlers being tested. On 2 tests (No. 4 and 5), the test cases were composed of eggs from two of the candlers being tested. The results of these tests, in which a candler at Plant No. 1 graded all the eggs in the test cases of eggs two times, are shown in Table II and the results at Plant No. 2 are shown in Table III.

The figures in these tables are the number of eggs the original candlers placed in the various grades when they graded the same eggs the second time. In 20 of the 40 tests in which candlers graded the same eggs a second time, they placed more eggs in the Grade A class on the second grading than they did on the initial grading. Five of the tests were from Plant No. 1 and 15 from Plant No. 2. Seven of the 20 tests in which the eggs were upgraded on the second test were white egg samples and 13 were brown egg samples.

In every test except one, all the brown egg candlers compared at Plant No. 2 placed more eggs in Grade A class on the second grading than on the initial grading. The white egg candlers at Plant No. 2 (Table III) also tended to "up-grade" the eggs. In 18 of the 40 tests, the candlers classified more eggs as Grade B on the second grading than on the first grading.

For example, on Test No. 1 at Plant No. 1, the test cases of white eggs were originally graded by Candler "X"; on her first grading she placed 360 eggs in the Grade A classification; 240 in the Grade B and 120 in Grade C. When Candler "X" regraded these same eggs, the following day, she reported 666 Grade B, 33 Grade C and no Grade A eggs; on Test No. 2 at the same plant, the test cases were originally candled by Candler "Y". According to her first grading, there were 360 Grade A, 240 Grade B and 120 Grade C eggs. When she recandled these eggs, she found 404 Grade A, 208 Grade B, and 76 eggs Grade C.

One white egg candler and one brown egg candler at each plant was tested on each of the ten tests. Fourteen of these tests were at Plant No. 1 and only 4 at Plant No. 2. Twelve were white egg tests and only 6 were brown egg tests. In only one test out of the 40 tests were more eggs placed in Grade C in the second grading, although three tests showed the same number of Grade C eggs on the second test. The large number of "Checks" found on the second or test grading may have come from the eggs originally classified as Grade C because eggs are placed in the Grade C category due to poor shell quality.

These data show that there was considerable inconsistency between the first and second grading of the same eggs by all of the candlers tested.

There was a time lapse of 12 to 24 hours between the first and second grading of the eggs which should cause some deterioration in the quality of the eggs; however, in general the eggs were graded higher the second grading than in the original grading.

Effect of Variation in Grading on the Value of the Test Samples

Based on the original grading, the value of the test sample cases of white eggs at Plant No. 1 was $14.18 and the brown eggs $13.82 (Table IV), but based on the second grading, the value of the test sample cases of eggs ranged from $13.04 to $14.86 for the white eggs, and from $11.55 to $14.70 for the brown eggs.

Based on the original grading at Plant No. 2 the value of the test sample cases of white eggs was $12.95 and the brown eggs $12.41. Based on the second grading, the value of the test samples of white eggs at Plant No. 2 varied from $11.46 to $13.34, and the value of the test samples of brown eggs varied from $11.78 to $13.03 per case.

TABLE II

The Number of Eggs Placed in the Various Quality Grades on the Second or Test Grading of the Same Eggs by the Same Candler on Each of 12 tests, Plant no. 1.

| TEST | White Eggs Grade A (360)* | White Eggs Grade B (240)* | White Eggs Grade C (120)* | Brown Eggs Grade A (360)* | Brown Eggs Grade B (240)* | Brown Eggs Grade C (120)* |
|---|---|---|---|---|---|---|
| 1 | 0 | 666 | 33 | 511 | 122 | 50 |
| 2 | 404 | 208 | 76 | --- | --- | -- |
| 3 | 208 | 383 | 105 | 248 | 321 | 103 |
| 4 | --- | --- | --- | --- | --- | --- |
| 5 | --- | --- | --- | --- | --- | --- |
| 6 | 267 | 334 | 87 | 466 | 200 | 42 |
| 7 | 234 | 372 | 100 | 200 | 433 | 66 |
| 8 | 269 | 333 | 89 | 112 | 447 | 104 |
| 9 | 342 | 273 | 79 | 520 | 86 | 94 |
| 10 | 169 | 415 | 101 | 245 | 364 | 70 |
| 11 | 239 | 383 | 55 | 98 | 492 | 97 |
| 12 | 120 | 523 | 56 | 614 | 59 | 27 |

*The Number of Egg placed in the Grade on the Original Grading.

TABLE III

The Number of Eggs Placed in the Various Quality Grades on the Second or Test Grading of the Same Eggs by the Same Candler on each of 12 tests, Plant No. 2.

| Test | White Eggs | | | Brown Eggs | | |
|---|---|---|---|---|---|---|
| | Grade | | | Grade | | |
| | A (360)* | B (240)* | C (120)* | A (360)* | B (240)* | C (120)* |
| 1 | 444 | 180 | 60 | 288 | 336 | 84 |
| 2 | 132 | 504 | 48 | 432 | 180 | 84 |
| 3 | 396 | 228 | 48 | --- | --- | -- |
| 4 | --- | --- | -- | 540 | 102 | 72 |
| 5 | 408 | 192 | 72 | 636 | 24 | 48 |
| 6 | 324 | 300 | 72 | 528 | 72 | 96 |
| 7 | 300 | 240 | 120 | --- | --- | -- |
| 8 | 252 | 336 | 86 | 624 | 24 | 48 |
| 9 | 516 | 108 | 60 | 504 | 72 | 108 |
| 10 | 480 | 60 | 120 | 540 | 48 | 72 |
| 11 | 420 | 144 | 120 | 576 | 30 | 78 |
| 12 | 276 | 216 | 144 | 552 | 36 | 72 |

*The number of eggs placed in the grade on the original grading.

Table IV

The average, high and low value of one case test samples of eggs based on the grading by different candlers compared to the value based on the original grading*.

| | Value Based on Original Grading | Value based on test grading of identical samples | | |
|---|---|---|---|---|
| | | Low Value | Ave. Value | High Value |
| Plant #1 White Eggs | $14.18 | $13.04 | $13.74 | $14.86 |
| Plant #1 Brown Eggs | 13.82 | 11.55 | 13.68 | 14.70 |
| Plant #2 White Eggs | 12.95 | 11.46 | 12.56 | 13.34 |
| Plant #2 Brown Eggs | 12.41 | 11.78 | 12.40 | 13.03 |

*Computed on the basis of the average yearly price per dozen.

Summary and Conclusions

1. These tests indicated a wide variation in the grading of identical samples of eggs by different candlers.

2. The difference in the grading of identical samples of eggs by 27 different candlers was highly significant in all of the 48 tests involved.

3. There was considerable variation in the candling of the same eggs at different times by the same candler. While the lapse of 12 to 24 hours between the first and second grading would presumably result in some lowering of quality, yet these tests in many instances showed actual "up grading" of the eggs on the second test, but the large number of "checks" found on the second grading reduced the value based on the second grading.

4. There was as much variation between candlers in the classifying of Grade C eggs as there was in the classifying of Grade A and Grade B eggs.

5. The value of the one case identical test samples of eggs varied from $2.27 less to $0.88 cents more per case than the value of the eggs based on the original grading due to the variation in the grading by the different candlers.

6. The variation in the grading of identical samples of eggs by different candlers indicates the need for a mechanical candling device to eliminate the human element of judgment in determining egg quality.